Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

Station Paper No. 126

June 1961

Reserve
1.9622
S45St2

Growth of Outstanding Nursery Seedlings of *Pinus elliottii* Engelm. and *Pinus taeda* L.

by

John C. Barber and David F. VanHaverbeke

U.S. DEPT. OF AGRICULTURE
LIBRARY
SEP 20 1961
CURRENT SERIAL RECORDS

U.S. Department of Agriculture
Forest Service
Southeastern Forest Experiment Station
Asheville, North Carolina

This project is in cooperation with the Georgia Forest Research Council and the Georgia Forestry Commission.

Growth of Outstanding Nursery Seedlings of *Pinus elliottii* Engelm. and *Pinus taeda* L.

by

John C. Barber and David F. VanHaverbeke

Forest geneticists need to isolate individual trees with outstanding characteristics for studies of inheritance and for use in breeding programs to develop superior strains. Selection of outstanding seedlings in the nursery is one method of obtaining possible superior individuals. The feasibility of this method depends on the correlation of characteristics exhibited in the seedling stage with those at economic maturity or some other chosen point in the life of the tree.

In the South, slash pine (*Pinus elliottii* Engelm.) and loblolly pine (*Pinus taeda* L.) seedlings are grown as 1-0 stock in nurseries that produce from 20 to 100 million seedlings annually. Seedling heights normally range between 6 and 12 inches, depending upon nursery conditions. Nursery-grown trees are concentrated under near-uniform environmental conditions, minimizing the contribution of environmental factors to variation among seedlings. However, even under the best nursery conditions, soil, microclimate, or other factors may cause considerable variation in seedling growth and development.

Ellertsen (1955, 1957) has reported on nursery selection studies conducted by the Tennessee Valley Authority involving loblolly, shortleaf (*Pinus echinata* Mill.), and white (*Pinus strobus* L.) pines. Outstanding seedlings were measured and tagged. The 25 adjacent seedlings were measured and a superiority value computed for each selected seedling. Seedlings with the highest superiority rating were selected at the approximate rate of 1 per 200,000 seedlings. These seedlings were outplanted and an "average" seedling from among the 25 was used as a check. Five of every 8 selections made over a 6-year period are outgrowing the controls among the 285 planted.

In a similar study in Texas, Zobel et al. (1957) selected loblolly seedlings on a visual basis without measurement criteria. They selected outstanding, average, and inferior seedlings at each location from beds sowed with equal-sized seed of a single source. After 4 years, 90 percent of the outstanding seedlings had retained their superiority in height and diameter over average seedlings and superiority over inferior seedlings in 100 percent of the trials. Average seedlings had exceeded inferior ones in height 88 percent and in diameter 85 percent of the time.

The question of whether the superiority of individual seedlings is due to genotype, seed size, early germination, or some other factor is still unanswered. The literature indicates that large seed tend to produce large seedlings (Hough, 1952; Fowells, 1953; Righter, 1945) and that seed size affects rate of germination (Fowells, 1953). Righter (1945), using graded seed of hybrid and selfed progeny, reports that seed size is not correlated with inherent vigor and concludes that selection based on seed size would be ineffectual within a progeny. He questions whether nursery selection in any form would be profitable. Fowells (1953), working with ponderosa (Pinus ponderosa Laws.) and Jeffrey (Pinus jeffreyi Grev. & Balf.) pine, found seed size affecting seedling size up to 5 years, but not longer. At 9 years there was no difference due to seed size, but large transplants had developed into significantly taller trees than small transplants.

Brown and Goddard (1959) reported that seed size is positively correlated with seedling size within the progeny of individual trees, but not between progenies of different trees. They further conclude that if the seed of any one progeny is graded and sown in a uniform environment "...then one should expect to select inherently vigorous seedlings with more than 50 percent accuracy."

Hough (1952), working with red pine (Pinus resinosa Ait.) single-tree progeny from a racial test, reported a significant relationship between seed weight and dry weight of 2-0 seedlings. He reported a highly significant correlation of average first year leader growth after planting with average green weight of 14-tree bundles of 2-1 stock. The regressions of total height at 5 years and again at 10 years with green weight were significant. He found a significant difference in the slopes of the 5-year and 10-year regressions which indicated that the heavier seedlings grew faster during the second 5-year period.

Lindquist (1948) found a correlation of branching characteristics in 1-1 Scotch pine (Pinus sylvestris L.) with branch forms of the parent trees. He also suggests that slow-growing seedlings be rejected to avoid using stock with inherently slow growth rates.

It should be pointed out that the work cited above, with the exception of Ellertsen, Brown and Goddard, and Zobel et al., was done with northern or western species. These species require several years in the nursery or transplant bed and have relatively slow juvenile growth when compared with slash and loblolly pine.

METHODS

In the fall of 1954 the four nurseries of the Georgia Forestry Commission were screened for outstanding seedlings. The selector walked through the nursery and observed 4 to 8 beds at a time, depending on species and conditions. Whenever an outstanding seedling was noted, a 30-inch cane was stuck in the ground beside it. Outstanding seedlings on outside rows, adjacent to failed areas or areas of low density, or in clumps of 3 or more, were automatically rejected. The criteria were flexible; height was the main basis for selection, with diameter, buds, or any other mark of vigor being considered. Totals of 582 slash and 571 loblolly seedlings were selected and lifted. This approximated a rate of 1 per 146,000 for slash and 1 per 44,000 for loblolly. The seedlings were lifted with spades and an "average" seedling was also taken from the same square foot of nursery bed for a control. The paired seedlings were kept together and subsequently planted adjacently in Twiggs County, Georgia, 1/ on an upland old-field site (figures 1 and 2).

1/ The planting site for this study was provided through the cooperation of Georgia Kraft Company.

Figure 1. --Loblolly pine seedlings after 2 years in the field. Row B is control seedlings with corresponding selected seedlings in row A. Row C is selected seedlings.

Figure 2. --Slash pine seedlings after 2 years in the field. Row B is control seedlings with corresponding selected seedlings in row A. Row C is selected seedlings.

RESULTS

At the end of the first growing season, the survival of seedlings in the select and control groups was nearly identical (table 1). Each year the real difference in average heights has increased (fig. 3). After 4 years selected loblolly pine seedlings were 16 percent and slash pine were 19 percent taller than the controls.

Table 1. --Survival and average heights of seedlings for four growing seasons in the field

Species	Group	Planted	1 year		2 years		3 years		4 years	
			Survival	Average height	Survival	Average height	Survival	Average height	Survival	Average height
		Number	Percent	Feet	Percent	Feet	Percent	Feet	Percent	Feet
Loblolly pine	Control	571	76	1.26	73	2.43	73	4.92	70	8.10
	Select	571	76	1.80	75	3.19	75	5.98	72	9.36
Slash pine	Control	582	69	1.33	69	2.56	69	5.48	67	9.43
	Select	582	69	1.86	69	3.70	68	6.99	65	11.24

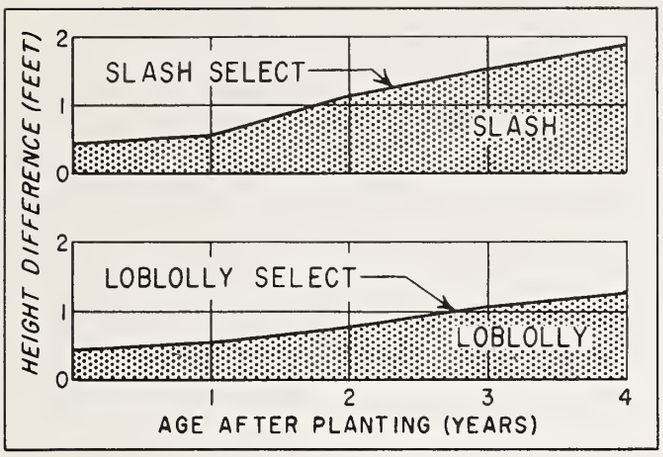


Figure 3. --Differences in average heights between selected and control seedlings for slash and loblolly pines.

Height data at 4 years for each species were subjected to statistical analysis. Only paired seedlings were used. The height of each select seedling was corrected by the difference in height at the time of planting. A "t" test of the adjusted differences indicated that select seedlings were taller than the controls, and that the difference was significant with 99 percent confidence.

The height frequency distribution curves for each species are strikingly similar with a large area under each curve having no overlap (fig. 4).

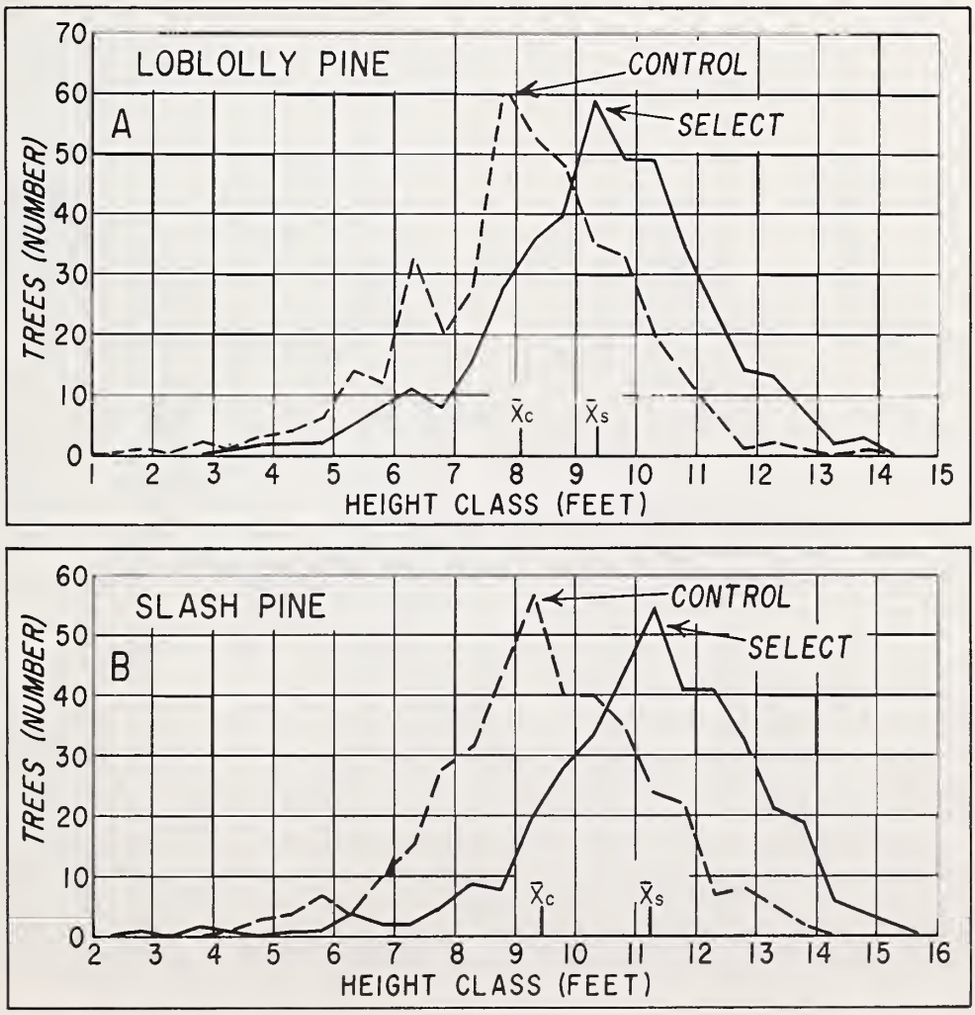


Figure 4. --Height frequency distribution of all loblolly pine seedlings (A) and all slash pine seedlings (B) after 4 years in the field.

The frequency distributions of the heights of selected seedlings, expressed as percent of height of control for each pair, are similar for both species (fig. 5). About 20 percent of the selected seedlings are exceeded by their controls, and about 30 percent exceeded their controls by more than 30 percent in height (fig. 6).

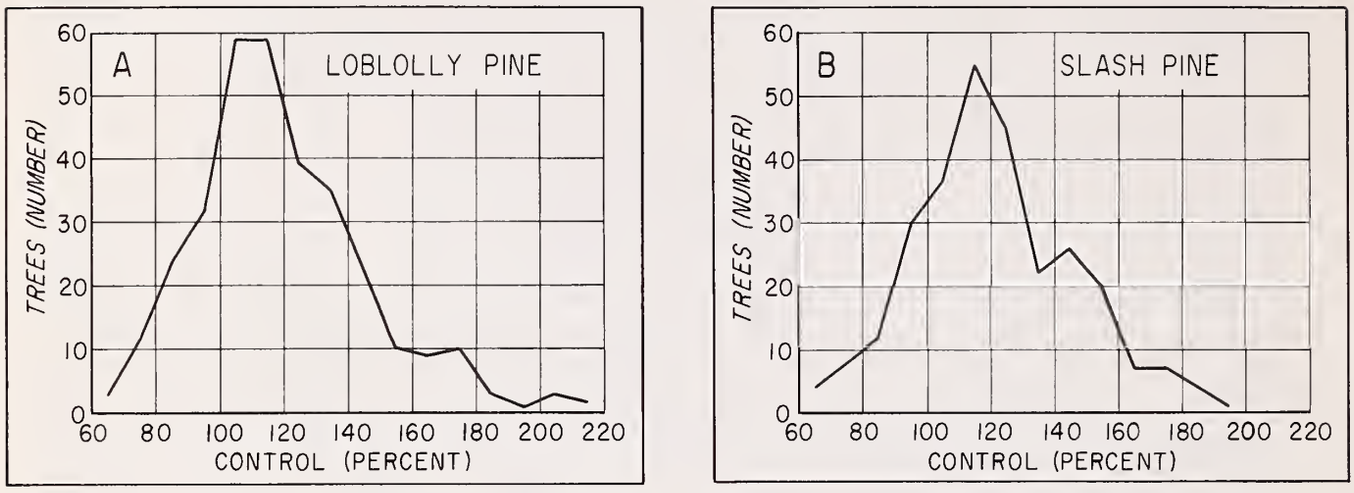


Figure 5. --Frequency distribution of height of selected seedling expressed as percent of control. (A) Loblolly pine 4 years in the field (340 pairs). (B) Slash pine 4 years in the field (289 pairs).

Figure 6. --Slash pine after 5 years in the field. The row on the right contains control seedlings with the corresponding select seedlings on the left. The difference in average heights between the rows is typical of the performance of the two groups.

Following the fourth growing season, fusiform rust (Cronartium fusiforme (A. & K.) Hedgc. & Hunt) infection was tallied by number and location of cankers (table 2). Selected seedlings of slash pine show no greater percentage of total infected trees than controls. Selected seedlings of loblolly have a higher percentage of infection than controls. For trees with stem cankers there is little difference between groups within species. The number of cankers per infected tree is slightly higher for selected seedlings of both species. The number of ramicorns 2/ per infected tree is higher among select than control seedlings. In view of the larger crowns on selected seedlings, it might be expected that there would be more infections on these trees because of the greater chance for a rust spore to land, germinate, and infect successfully.

Except in the control loblolly, the percentages of rust-free trees in all height classes are similar, indicating that the more vigorous trees are not more susceptible to rust per se (fig. 7). This may give a better opportunity to select for a combination of several desirable characteristics.

This study was not designed to determine differences between species. Although planted on the same tract, the slash and loblolly are not contiguous and probably have different microclimate and soil conditions. Therefore, any comparisons between species may be erroneous.

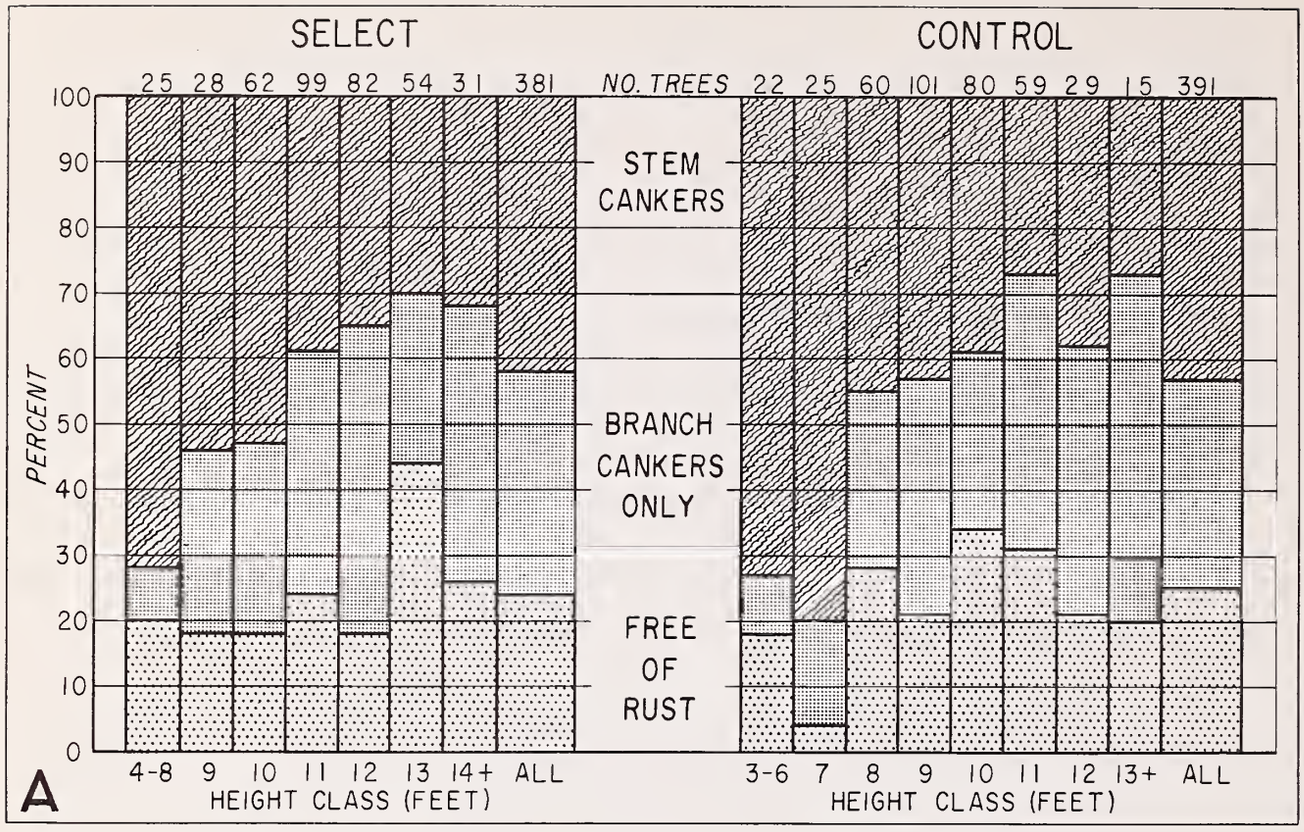
2/ A ramicorn is a branch of abnormally large size occurring at an acute angle to the stem, and in this instance associated with a canker. Ramicorns create large knots and are very slow to self prune.

Table 2. --Fusiform rust infection 4 years after outplanting 1/

Species	Group	Trees	All trees			Trees with branch cankers		Trees with branch and stem cankers		
			Infected	Cankers per tree	Ramicorns per tree	Trees with cankers 2/	Cankers per tree	Trees with cankers 2/	Branch cankers per tree	Stem cankers per tree
		Number	Percent	Average number		Percent	Average number	Percent	Average number	
Loblolly pine	Control	399	79	5.0	1.6	34	3.4	41	5.0	1.6
	Select	414	86	6.2	1.8	40	3.9	44	6.5	1.8
Slash pine	Control	391	75	5.0	2.4	32	2.6	40	5.7	1.6
	Select	381	76	5.7	2.8	34	3.5	39	6.2	1.7

1/ None of the differences in rust infection of control and select seedlings were statistically significant for either species.

2/ The difference between the sum of these percentages and the total percent infected represents trees which have stem cankers but not branch cankers.



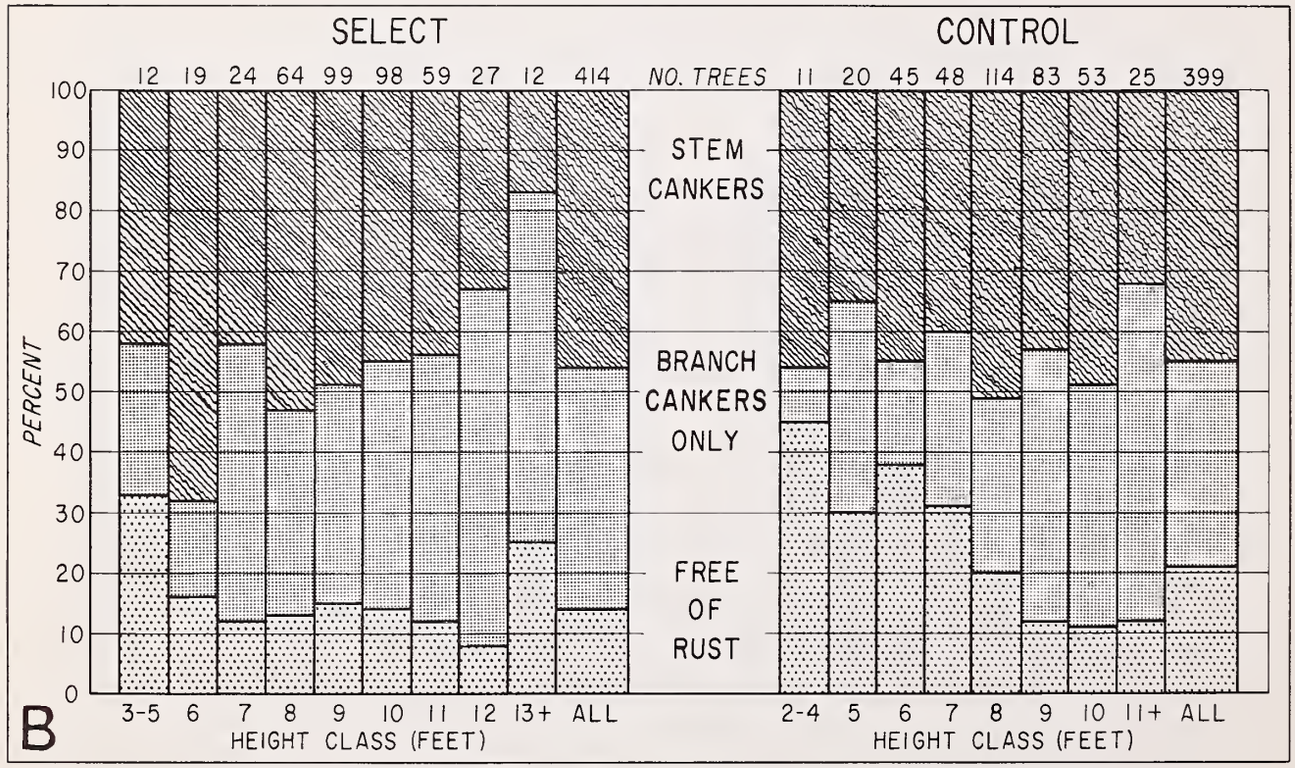


Figure 7. --Fusiform rust infection by height classes in (A) slash pine and (B) loblolly pine 4 years after planting.

The form of individual trees is quite varied in terms of straightness of stem and length, diameter, angle, and number of branches. To obtain an estimate of crown form, the 50 tallest select slash pines were measured and also the 50 select slash trees nearest the mean height for the select group. Each tree was examined and two determinations of the ratio of crown width at one-half height to total height were made and averaged. Each stem was also classified for straightness into one of three groups. There is little difference in form between the two groups, though the difference in average height is 22.5 percent (table 3).

Table 3. --Distribution of crown width and stem straightness in two groups of the selected slash pine seedlings

Crown width class 1/	Stem straightness class 2/			Total
	Straight	Slight deviation	Crooked	
	Number			Number
AVERAGE TREES--11.24 FEET				
Less than 0.30	11	2	-	13
0.31 to 0.40	14	12	1	27
Greater than 0.41	3	5	2	10
Total	28	19	3	50
TALLEST TREES--13.78 FEET				
Less than 0.30	7	4	1	12
0.31 to 0.40	13	14	3	30
Greater than 0.41	4	4	-	8
Total	24	22	4	50

1/ $\frac{\text{Crown width (feet)}}{\text{Tree height (feet)}}$

2/ Straight: No noticeable deviation from a perfectly straight stem.
Slight deviation: Slight sweep or crook which will not affect merchantability for any product.
Crooked: Crook or sweep severe enough to be noticeable when merchantable size is reached.

INTERPRETATION

In view of the literature on nursery selection and the data herein presented, we conclude that selection of outstanding slash and loblolly pine seedlings in the nursery is a feasible means of isolating outstanding trees for vigor. Our criteria were not as rigid as those of T. V. A.; however, we have obtained all the seedlings their methods would have selected plus many more. The final ratio of 1:44,000 for loblolly is probably higher than desirable because normally loblolly pine beds show more irregularity than slash, thus making accurate selection for vigor more difficult. Because of this, we would expect our selection of loblolly pine seedlings to be less effective.

Using a 3-man crew (one man selecting, two lifting) a nursery of 30 to 50 million trees capacity can be scanned in a day, and if the beds are reasonably uniform, they will yield 150 to 200 seedlings. Only a small percentage of these need to prove superior to justify the expenditure of manpower and money involved. In view of the limited number of outstanding seedlings evident in nursery beds, it is not feasible to use them directly for plantations or seed orchard establishment.

These selected seedlings are only the first step in isolating material. The test plantations established with them will be observed and further selections made for combinations of desirable traits (fig. 8).

Our data indicate a wide range of fusiform rust infection, ranging from none to more than 15 cankers per tree. It would be difficult to explain these differences in terms of "escapes" or other chance phenomena. Some of the most vigorous trees are free of rust, though more than three-fourths of the total number of trees are rust infected. The rust-free trees are apparently randomly scattered throughout the plantations.

The form of the faster growing slash pines is about the equivalent of that in slower growing material and indicates that crown form is probably not highly correlated with vigor. Form estimates were not made in loblolly pine because of the confounding of tip moth damage.

Nursery selection appears to offer good potential as a means of isolating superior individuals for breeding purposes. If the performance of the selected seedlings continues as it has the first 4 years, the degree of success will be high enough to justify the expenditure of considerable effort to isolate material in the nurseries. Thousands of seedlings can be screened rapidly and selection criteria can be adjusted to obtain populations of the desired size. However, it will probably be feasible to select only for vigor. Selection for characters, such as stem form, wood quality, and pest resistance will probably have to be delayed until the trees are well established in the field. The relative efficiency of selection for several characters simultaneously may be less here than by other methods.

SUMMARY

Based on results after 4 years of growth, selection of outstanding nursery seedlings is a feasible means of isolating trees of unusual genetic constitution. On the average, 4-year-old selections of loblolly and slash pines exceed their controls in height by 16 percent and 19 percent, respectively. Statistical tests indicate the differences are highly significant. Records of fusiform rust infection show no difference in percent of trees infected between the slash groups, and a slightly higher proportion of selected loblolly infected. For both species there were more cankers per tree on the infected outstanding seedlings, though this may be attributed in part to their larger size. The form of the faster growing slash pine selections appeared no different from a slower growing group. Survival of select and control groups was about the same for both species.

Figure 8. --Very vigorous slash pine after 4 years in the field. The select seedling on left corresponds to the control on the right. The select seedling is free of fusiform rust, growing rapidly, and has "average" form. (Pole is 12.0 feet.)

LITERATURE CITED

Brown, C. L., and Goddard, R. E.
1959. VARIATION IN NURSERY-GROWN SEEDLINGS FROM INDIVIDUAL MOTHER TREES IN A SEED-PRODUCING AREA. Fifth South. Conf. Forest Tree Impr. Proc., pp. 68-76.

Ellertsen, Birger W.
1955. STATUS OF THE SUPER-SEEDLING STUDY AT TVA'S CLINTON FOREST NURSERY - FALL 1954. Third South. Conf. Forest Tree Improv. Proc., pp. 35-42.

_____
1957. PROGRESS IN NURSERY SELECTION OF LOBLOLLY, SHORTLEAF AND WHITE PINE SUPER-SEEDLINGS. Fourth South. Conf. Forest Tree Impr. Proc., pp. 132-138.

Fowells, H. A.
1953. THE EFFECT OF SEED AND STOCK SIZES ON SURVIVAL AND EARLY GROWTH OF PONDEROSA AND JEFFREY PINE. Jour. Forestry 51: 504-507.

Hough, A. F.
1952. RELATIONSHIPS OF SEED SOURCE, SEED WEIGHT, SEEDLING WEIGHT AND HEIGHT GROWTH IN KANE TEST PLANTATION. U. S. Forest Serv. Northeast. Forest Expt. Sta. Paper 50, 4 pp.

Lindquist, Bertil
1948. GENETICS IN SWEDISH FORESTRY PRACTICE. Chronica Botanica Co., Waltham, Mass. 173 pp.

Righter, F. I.
1945. PINUS; THE RELATIONSHIP OF SEED SIZE AND SEEDLING SIZE TO INHERENT VIGOR. Jour. Forestry 43: 131-137.

Zobel, B. J., Goddard, R. E., and Cech, F. C.
1957. OUTSTANDING NURSERY SEEDLINGS. A PROGRESS REPORT. Texas Forest Serv. Res. Note 18, 14 pp.

Agriculture--Asheville

NATIONAL AGRICULTURAL LIBRARY
1022591216

* NATIONAL AGRICULTURAL LIBRARY
1022591216